



Seattle

122nd ASEE Annual
Conference & Exposition

June 14 - 17, 2015
Seattle, WA

Making Value for Society

Paper ID #12402

A Female Oriented Capstone Experience: Generations of Engineers Passing the Torch

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A Female-Oriented Capstone Experience: Generations of Engineers Passing the Torch

This paper describes how several students in the undergraduate Civil Engineering program at Lawrence Technological University, interested in focusing on diversity and a creating a meaningful experience in their senior year, formed the first all-female capstone team. The project the team selected was the conceptual design of a performance and visual art center for an existing nonprofit “village” that houses physically and emotionally abused girls. Each team member was responsible for the design of a component of the project based on her civil engineering subdiscipline. An all-female group of industry practitioners agreed to serve as mentors to the capstone team throughout the project cycle. With significant input from the practitioner-mentors, the students designed the project and not only presented to faculty and advisory board members, they also presented to the local chapter of a female-based construction industry association. Most importantly, the students evolved from mentees to mentors. They shared their knowledge of civil engineering, their work on the capstone project, and their college experiences through presentations and STEM activities with groups of middle school-aged, at-risk girls at the village. Thus, the girls were provided with two rare experiences: they learned about civil engineering concepts and how they apply to their everyday lives, and the girls were also able to interact with confident and caring female mentors who demonstrated that opportunities are unlimited for women in college and in industry.

Keywords: mentor, female, STEM, capstone

Introduction

It is axiomatic that a society’s elders must share their knowledge and wisdom if the following generation is to survive and thrive. Similarly, it is incumbent upon the present generation of engineering practitioners to pass on their knowledge and expertise so the next generation of engineers can develop into competent professionals.

Mentoring capstone students provides an excellent opportunity for practitioners to impart their wealth of knowledge. Students can learn general engineering concepts, as well as subdiscipline-specific skills useful for the creation of accurate designs and realistic project management plans.

During the 2013-2014 academic year, an all-female capstone team learned the value of mentoring from female construction industry practitioners. Moreover, utilizing their capstone project as a platform, the team members shared their engineering knowledge, along with their college experiences, in the mentoring of at-risk girls.

Capstone Execution

The major design and project management experience for the Civil Engineering Program (Program) at Lawrence Technological University is a fall/spring sequence of two, two-credit courses, CE Design Project 1 (Project 1) and CE Design Project 2 (Project 2). In execution, the sequence is somewhat akin to an independent study course. Students are responsible for forming five-person teams, identifying a project, and generating conceptual designs and project management plans. Each team member is tasked with incorporating one of the civil engineering

subdisciplines into the project. Although faculty must give final approval of proposed projects, student teams choose their projects and sites.

Project 1 addresses the initiation and early planning for the proposed structure, including site selection, ascertaining the “client’s” needs, and analyzing alternative designs in the context of real-world constraints. In Project 2 students expand on the work performed in Project 1 by refining plans and designs, resulting in final conceptual subdiscipline designs and a complete project management plan.

Faculty involvement in the capstone is extensive and includes a course coordinator who performs various administrative functions, such as recording grades and disseminating rubrics. Each team is assigned a faculty advisor who serves as the team’s unofficial senior engineer. Faculty members also advise students on their civil engineering subdisciplines.

Team deliverables for the capstone include poster presentations, oral and written proposals, and oral and written progress reports. Individual deliverables consist of periodic written subdiscipline technical reports documenting the various elements of designs and project management plans.

Capstone Team and Client Introduction

Approximately 15% of the Civil Engineering students at Lawrence Technological University are female. In summer 2013, five female students considered the benefits of creating the first-ever all-female team for the Civil Engineering capstone. After some discussion and compromise, the students agreed on which team member would have the responsibility for which civil engineering subdiscipline: structural, geotechnical, transportation, water resources, and construction. The students also chose a team name: Women of Steel (WoS), and requested the author of this paper to serve as faculty advisor.

It is faculty’s task to create a capstone experience that is technically challenging and requires sufficient work to satisfy four upper-level credits in civil engineering. Ultimately, however, it is the students who must decide if they are going to push themselves to earn a high grade, to make the experience special, or to just do the minimum necessary to pass the course (as well as attain the appropriate level of achievement for assessed student outcomes). Generally, a capstone team is not unlike any other student group or team assembled within the purview of a course; some approach the capstone sequence as simply more hoops to jump through, while others give the bare minimum effort to secure a passing grade. Then there are students that demonstrate high expectations for Project 1 and Project 2, as well as for themselves. Those teams select projects that are interesting, challenging, and personally meaningful, committing to investing the time and effort to yield an exceptional experience. Indeed, the capstone project can be a special time for students, providing an opportunity to conduct in-depth research and investigation, collaborate as a team at a much higher level than a group writing a lab report, and even interacting with “clients” and industry practitioners in a professional manner.

Women of Steel proved to be one of those teams that sought an extraordinary capstone experience. The members discussed at length potential clients and projects, with the ultimate

goal of completing their undergraduate degrees with a worthwhile endeavor they would be proud of and find challenging.

WoS identified Vista Maria¹, located in Dearborn Hills, Michigan, as a desirable client, based on its commitment to providing alternative education, life skills training, and housing for at-risk girls. The mission of Vista Maria provides: “To heal Michigan’s victimized girls and women with best-practice treatment programs designed to meet their unique needs while serving other vulnerable children and families within Southeast Michigan.”²

Program Student Outcomes/Course Objectives

The Program’s student outcomes are adopted from the *Civil Engineering Body of Knowledge, 2nd edition*³ (BOK2), promulgated by the American Society of Civil Engineers. The capstone sequence addresses numerous outcomes, such as design, problem solving, sustainability, and teamwork. The salient outcome for the team’s choice of a project for Vista Maria and its residents, however, is BOK2 Outcome 4: “Demonstrate the incorporation of social sciences knowledge into the professional practice of engineering.”⁴

There is additional discussion as to the application of Outcome 4 provided in the Appendix to BOK2: “...Professional civil engineers must work within a social framework; understanding it is foundational to effective professionalism...In practice, virtually all projects...involve varying degrees of social sciences knowledge, including the economic and sociopolitical aspects. Engineers must be able to recognize and incorporate these considerations into the development, delivery, and evaluation of solutions to engineering problems.”⁵

Support by the Program for projects similar to Vista Maria is also demonstrated in the course objective mapped to Outcome 4, as set forth in the Project 1 syllabus, which provides in pertinent part: “...conduct preliminary research of stakeholder needs and generate a proposal describing a project that addresses real-world constraints and issues, including sustainability and other sociopolitical considerations.”⁶

While it is important for assessment purposes that the social sciences are addressed in capstone projects, teams rarely address the outcome with more than a surface treatment. For example, project deliverables often only discuss unemployment statistics in the project site area. The members of WoS, however, were determined to reach a whole new level in the consideration of the social sciences.

Capstone Project Overview

The Vista Maria campus is approximately 37 acres and is encircled with an 8’ high security fence. Ensuring the safety of the girls and other residents is a paramount concern of the Vista Maria administration, thus visitors are required to enter through a guarded gate. There are numerous structures on the campus, including classrooms, housing units, maintenance buildings and administrative facilities.

The Woman of Steel’s initial campus visit in early September 2013 served three main purposes. First, the students sought to determine if Vista Maria management would consider cooperating with a team of college students working on a conceptual capstone project. Indeed,

Vista Maria representatives stated that they welcomed such interaction and they would fully support and cooperate with WoS. Secondly, the team wanted to ascertain what Vista Maria's needs were with respect to new facilities. Maintenance personnel participated in a walk-through of many of the structures to review their usage and condition. Discussions were held regarding the informal campus master plan, how the existing structures were used, and what was planned for the near and long term.

A final purpose for the visit was to conduct a general exterior site investigation, with the information collected used to inform the project scope, location, and various components of the project management plan. The students took numerous pictures and recorded information regarding potential building sites, possible obstructions, logistical challenges, pedestrian and vehicular routes, etc.

The Women of Steel's initial approach, prior to in-depth discussions and the site visit, was to create a conceptual design for a dormitory/apartment for campus residents. Vista Maria, however, had already secured the financing and approved a design to build additional on-campus living quarters during the upcoming year. Consequently, the dormitory was disregarded and the team considered other alternatives.

During further discussions on a potential project, the WoS team members realized that when they toured the campus there was no separate structure dedicated to artistic expression. The team determined that an appropriate project to serve the girls' needs would be a dedicated facility for art and performance classes. Moreover, additional research suggested that participating in artistic endeavors has positive effects on children who have been psychologically and physically abused.⁷ Vista Maria representatives were enthusiastic about the concept, considered it an appropriate use of campus space, and gave it full support.

The team subsequently created the initial concept for Casa Esperanza—House of Hope—a 17,000 s.f. multi-purpose fine arts center. The center features a 300-seat auditorium with a stage, a music room, art rooms, and an atrium/art gallery. Appurtenant to the main project, and in deference to the civil engineering subdisciplines required by the capstone course sequence, are an outside amphitheater (geotechnical), revised and updated campus security entrance (transportation), a multi-purpose path throughout the campus (transportation), and updated components of a stormwater management system (water resources) that addresses the building site and other areas on campus.

Industry Practitioner Involvement

Involving industry practitioners is a successful approach for enhancing the capstone experience for engineering students^{8,9}. In the capstone sequence at Lawrence Technological University students are afforded two formal opportunities to meet with subdiscipline mentors, once in fall term and once in spring term. However, in consultation with the faculty team advisor, Women of Steel team members decided that they wanted additional opportunities to interact with industry practitioners. Moreover, to carry on the gender-based theme, the team members agreed that it would be interesting and instructive to interact with female engineering and construction practitioners.

Female practitioners in several subdisciplines were contacted and requested to participate as mentors to the WoS. All readily agreed, and they were especially enthusiastic when informed that the capstone project involved Vista Maria. Mentor expertise includes transportation engineering, structural engineering, geotechnical engineering, water resources, architecture, building project management, and transportation project management. In fall term there were initial meetings with the mentors, but the majority of the sessions occurred in spring term.

Another aspect to the professional mentorship was the interaction of WoS with the Detroit chapter of the National Association of Women in Construction (NAWIC). WoS met with various members of NAWIC and was invited to present an overview of Casa Esperanza at a joint meeting of NAWIC and the Michigan chapter of the Design-Build Institute of America. In furtherance of the relationship, a couple of local NAWIC executive board members attended the January 2014 mentoring session of the girls at Vista Maria.

Women of Steel Mentoring Visits to Vista Maria

In fall 2013 Women of Steel, taking a cue from their female industry mentors, decided that they should also mentor the next generation of potential engineers – the girls of Vista Maria. The team visited with twenty-two middle school-aged girls and three of their teachers, utilizing STEM (science, technology, engineering and mathematics) exercises to stimulate interest in engineering. While some of the girls were at first too shy to take part, by the end of the session almost all participated.

One exercise entailed the girls, in teams of three, cutting out pictures in magazines to make collages of what they thought engineering is. WoS members walked among the teams, assisting the girls by discussing their choices of pictures and by explaining the various types of engineering. Once the collages were complete, each team reported out – presented to the entire group – explaining their choices and their understanding of engineering.

Another STEM exercise conducted was the “marshmallow challenge,” where the girls again worked in teams to build supports of raw spaghetti to hold up a marshmallow, demonstrating the concept of a supported structure. The WoS also participated, and the girls especially enjoyed it when their mentors’ design suffered a catastrophic failure resulting in the marshmallow tumbling to the floor!

After lunch the team members took turns discussing their civil engineering subdisciplines, why they chose civil engineering, and the challenges women face in a male-dominated industry. The session ended with WoS promising to return to visit the girls.

Determined to fulfill their commitment to “passing the torch” to the next generation of potential engineers, WoS made good on the promise to come back to Vista Maria. For the mentoring session in late January 2014, the team conducted a traditional STEM team-building exercise. The “tower construction challenge” required two girls to assist a blindfolded teammate with assembling a tower constructed of large, plastic drinking cups. The girls enjoyed the competition and the engineering challenge of constructing the largest structure.

Seeking to provide a range of STEM experiences for the girls, including one with practical applications, WoS created a two-part exercise. For the first component, WoS conducted a short presentation of its capstone project, Casa Esperanza, providing an overview of the project scope and discussing how each of the civil engineering subdisciplines contributed to the entire project. The presentation served two purposes: 1) the girls were introduced to the design and project management processes, including a discussion on various constraints the team must consider when moving a project from initiation to execution; and, 2) WoS demonstrated to the girls what college level work entailed, including course and professor expectations, timelines and deliverables, etc.

For the second exercise the girls were provided a simple set of design drawings for Casa Esperanza—a floor plan, an elevation, and a site plan. In teams they were asked to review and comment on the design and to consider what elements they might prefer in the project. In essence, the girls were asked to act as clients, critiquing the WoS’s work product and providing design input. The girls marked up the plans as they discussed their individual visions for the structure, then reported out their thoughts and ideas to the entire group.

The plan review exercise was employed to engage the girls at different levels by encouraging them to apply their critical thinking skills in a more practical manner. The exercise required the girls to play the part of stakeholders and critically review the WoS’s approach, while envisioning what the original design would look like and how they would utilize the facility. The next level of review required the girls to consider what changes they may want implemented for the Vista Maria to better address their needs. The WoS subsequently revised the floor plan by adding a dance studio, based on the input of the “clients.”

Observations and Perspectives on the Female-Based Capstone

When discussing the capstone in general, each Women of Steel team member thought the experience was arduous and time-consuming, requiring much more than a standard four-credit course. Compounding the challenge is the fact that Lawrence Technological University is a commuter school and all the WoS members were employed part-time for construction or engineering-related firms. Ultimately, however, all five members agreed that the result was worth the extra effort. Moreover, they generally believed the all-female team was empowering, and that bonding with female teammates was valuable.

From the faculty advisor’s perspective, the negative comments from male members of other capstone teams regarding an all-female team seemed to provide an impetus for Women of Steel to work harder and generate higher-level deliverables, while at the same time also dispelling any negative stereotypes about the ability of women to work together in teams. Indeed, the team-based deliverables generated by WoS—a poster presentation, oral presentations, and progress reports—were graded consistently higher than the other teams.

Irrespective of the amount of work required for the capstone, the WoS team believed that the interaction with Vista Maria, especially the mentoring of the girls, significantly enriched the capstone experience. Knowing that the girls looked up to them fueled the team’s enthusiasm and commitment. Interestingly, the WoS team members, to a person, did not feel that future

capstone projects should have a service requirement as a deliverable. While they believed their involvement was invaluable to their experience, they nonetheless felt that students would resent compulsory participation in service. WoS was all-in on spending additional time with the female industry mentors, as well as the mentoring of the girls of Vista Maria, but nonetheless preferred to have the choice as to whether to participate in a service-type activity.

WoS also found the interaction with the female mentors was helpful on various levels. Besides assisting with the technical aspects of civil engineering design and project management, the mentors shared their perspectives and advice on career choices and work-life balance.

The mentors, too, found the experience rewarding. For the most part they did not have much contact with female engineers when they were new graduates and they enjoyed critiquing the technical deliverables of the team members, as well as sharing their work experiences. From the mentors' perspective, the construction and design industry needs more diversity, and mentoring females and other underrepresented groups is an important duty, as well as personally rewarding.

Once in a great while there is a team of students who desire more from the capstone—they strive for excellence in their project and in the entire experience. The Women of Steel was such a team, not only gaining knowledge from industry mentors, but also developing into mentors themselves. The team members passed the torch of knowledge and experience by demonstrating to young females the value of teamwork, hard work, commitment to a goal, confidence, oral and graphic communication skills, and the value of continuing education. And, hopefully, the girls of Vista Maria also learned from the Women of Steel capstone team the importance of mentoring the next generation.

As a final note from the author, the decision to write this paper to record the Women of Steel's capstone experience arose organically; that is, this was not a planned research project. Rather, it started as just an interesting idea to have an all-female team. The interaction with the female industry mentors and the mentoring of the girls at Vista Maria were not pre-planned activities. Rather, they were ideas that evolved as the team and project evolved.

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